LOWER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit (AU): Lower Arkansas River – Maize to Derby

Water Quality Impairment: Chloride

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Part of Arkansas River (Maize), Arkansas River (Wichita)

County: Sedgwick

HUC 8: 11030010, 11030013

HUC 11 (HUC 14s): 11030010020(080)
11030013010(050,060)

Ecoregion: Central Great Plains, Wellington-McPherson Lowland (27d)
Flint Hills (28)

Drainage Area: 111.1 square miles

Main Stem Segments: 11030010 (AU Station 536): part of Arkansas River (1)
11030013 (AU Station 729): Arkansas River (part of 3, 9)

Main Stem Segments with Tributaries by HUC 8 and Watershed/Station Number:

Table 1 (a-f)

a.

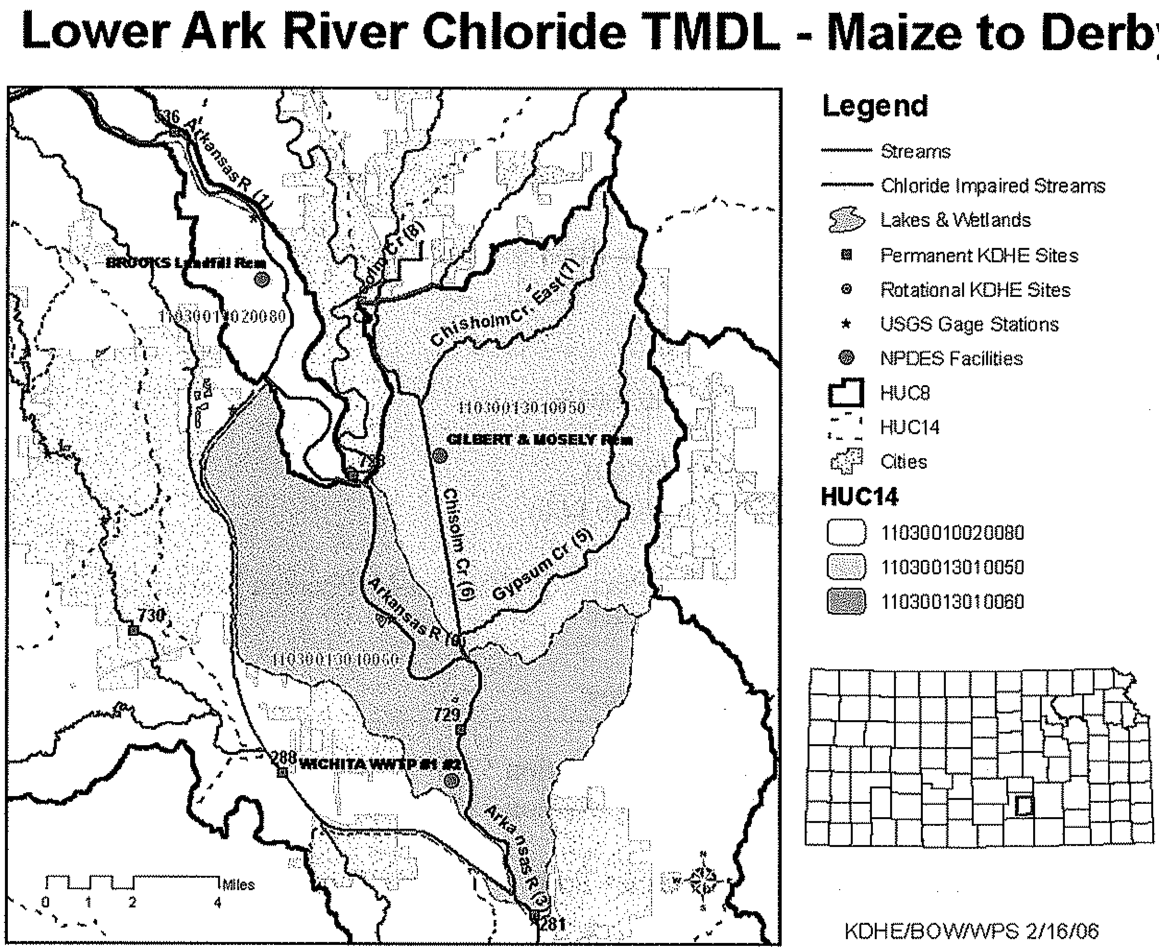
HUC8	**11030010**		
Watershed	**Arkansas River (Maize)**		
Station			
536	Arkansas R (1 - part)	Big Slough (9011)* Gar Cr (8)*	S. Fk. Big Slough (9035)*

* Not covered by this TMDL, see Ark River – Hutchison to Maize Chloride TMDL

b.

HUC8	**11030013**		
Watershed	**Arkansas River (Wichita)**		
Station			
729	Arkansas R (3 - part)	Chisholm Cr (4) Chisholm Cr (6) Chisholm Cr (8 -part)	Gypsum Cr (5) E. Chisholm Cr (7)

Figure 1. Map of Study Area



Designated Uses: Domestic Water Supply

303(d) Listings: 2004 Lower Arkansas River Basin Streams
2002 Lower Arkansas River Basin Streams
1998 Table 1: Impaired streams impacted by non-point and point sources

Impaired Use: Domestic Water Supply, Aquatic Life Support

Water Quality Standard: Domestic Water Supply: 250 mg/L at any point of domestic water supply diversion (K.A.R.28-16-28e(c)(3)(A))

Aquatic Life Support [Acute criterion]: 860 mg/l for (KAR 28-16-28e(c)(2)(D)(ii))

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the domestic water supply criteria listed in table 1a in subsection (d), at ambient flow, due to intrusion of mineralized groundwater, the existing water quality shall be maintained, and the newly established numeric criteria for domestic water supply shall be the background concentration, as defined in K.A.R. 28-16-28b(e). Background concentrations shall be established using the methods outlined in the ''Kansas implementation procedures: surface water quality standards,'' as defined in K.A.R. 28-16-28b(gg), available upon request from the department. (K.A.R. 28-16-28e(c)(3)(B) and (b)(9))

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of groundwater quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical or radiological contaminant or infectious microorganism in groundwater resulting from surface water infiltration or injection. (KAR 28-16-28e(c)(5)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2004 303(d): Not Supporting Domestic Water Supply Use, and Aquatic Life Support at Maize

Stream Flow and Water Quality Monitoring Sites: USGS 07143375 and 07144550; KDHE 536, 729, and 281; USGS 07144200 and KDHE 728 and 288 used only for load allocation calculations (**Tables 2 and 3**)

Period of Record used: 1970-2005 (**Tables 2 and 3**)

Long Term Flow Conditions: Table 3

Hydrology: The USGS flow data are summarized in Tables 2 and 3. The Arkansas River gains significantly amount of flows from Maize to Derby. The three main tributaries are the Lower Arkansas River, Chisholm Creek, and Cowskin Creek. Both the Little Arkansas River and Cowskin Creek have low levels of chloride (**Table 2**). The water from these two streams helps to dilute the chloride in the Arkansas River.

Current Conditions: The KDHE monitoring station chloride data are summarized in **Tables 2-4**. Sample data for each sampling site were categorized into three seasons: Spring (April-July), Summer-Fall (August-October), and Winter (November-March) (**Tables 4-8**). No USGS station has a good collection of recent chloride data (since 1992).

Table 2. Monitoring Sites Summary

KDHE Sites	Period of Record	Ave Cl (mg/L)	Max Cl (mg/L)	# of Samples	# > 250 mg/L	# > 860 mg/L	Nearby USGS Gages	Stream
SC536 (Ark R at Maize)	1990-2005	471	948	93	80	2	USGS 07143375 (Ark R at Maize)	Ark R.
SC728 (Little Ark R. at Wichita-Ctr Ave)*	2000-2005	104	200	33	0	0	Estimated Flow by USGS 07144200 (Little Ark R at Valley Center)	Little Ark R.
SC729 (Ark R. at Wichita-S. Bridge)	2000-2005	315	598	33	23	0	USGS 07144550 (Ark R at Derby)	Ark R.
SC288 (Cowskin Cr in Wichita-Valley Ctr Floodway)*	1985-2005	75	123	140	0	0	Estimated Flow by USGS 07144550 (Ark R at Derby)	Cowskin Creek
SC281 (Ark R at Derby)	1985-2005	299	589	139	99	0	USGS 07144550 (Ark R at Derby)	Ark R.

*Not located in the area of interest and not impaired by chloride, data for load allocations

Table 3: USGS Gage Flow Statistics

Site	Maize	*Wichita-Ctr Ave**	*Wichita- S. Bridge***	*Valley Ctr Fldway***	Derby
Time Period	1987-2005	*1970-2005*	*1970-2005*	*1970-2005*	1970-2005
Drainage Area (square miles)	220.6	*80.3*	*57.9*	*89.6*	44.9
Mean Flow (cfs)	708	*442*	*1163*	*36.4*	1186
10% (cfs)	1320	*771*	*2489*	*80.6*	2530
25% (cfs)	547	*183*	*1045*	*32.6*	1070
Median (50%) (cfs)	266	*76.1*	*504*	*14.4*	517
Upper Quartile (75%) (cfs)	133	*42.6*	*290*	*7.3*	300
Upper Decile (90%) (cfs)	70.0	*25.2*	*191*	*3.9*	197
95% (cfs)	54.0	*17.7*	*164*	*2.9*	169
99% (cfs)	17.0	*8.2*	*117*	*1.4*	122

* Determined from the Valley Center gage flows by regression analysis
** Determined from the Derby gage flows by regression analysis

Table 4. Summary of Seasonal Chloride Data

	Spring Ave. (mg/L)			Summer/Fall Ave. (mg/L)			Winter Ave. (mg/L)		
KDHE Sites	Seasonal	Above Median Flow	At or Below Median Flow	Seasonal	Above Median Flow	At or Below Median Flow	Seasonal	Above Median Flow	At or Below Median Flow
SC536 (Ark R at Maize)	450	409	528	400	277	494	533	429	618
SC729 (Ark R. at Wichita)	291	252	394	277	169	363	365	281	407
SC281 (Ark R at Derby)	283	246	350	238	170	305	349	269	383

Because of the strong influx of chloride from the ground water, background concentrations were determined for all the monitoring stations (see Section 3 for more discussion). Load curves were established for the Domestic Water Supply criterion (250 mg/L) and the background levels by the following equation:

Load (tons/day) = flow (cfs) * Conc. (mg/L) * 5.4 (conversion factor) / 2000 (pounds/ton)

The domestic water supply criterion load curve represents the TMDL and is referred to as the TMDL load curve in this report, since any point along the curve denotes water quality for the standard at that flow (**Figures 2-4**). Historic excursions from the water quality standard are seen as plotted points above the TMDL load curve. Water quality standards are met for those points plotting below or on the TMDL load curve. The background load curves are only displayed in **Figures 2-4** if they are higher than the domestic water supply criterion (250 mg/L). In general, lower flow rates imply higher chloride concentrations in the streams.

All of the other supporting graphs and tables are in **Appendices A and B**.

<u>Site 536 (Maize)</u>: Excursions in each of the three defined seasons are outlined in **Tables 5 and 6**. Seventy-eight percent of the Spring samples and 83% of the Summer-Fall samples are above the domestic water supply standard. Ninety-five percent of the Winter samples are over the domestic supply criterion. Overall, 86% of the samples are above the domestic water supply standard. Two out of the 93 samples exceeded the Aquatic Life Support standard. The exceedances occurred during the Winter medium flows.

Since the streamflows in the Winter months are sustained mainly by the influx of the ground water, the background level at the station is determined using the Winter samples (see **Section 3**). For the Maize station, the background level is set at 620 mg/L. The exceedances over the background level occurred mainly at medium to low flows (**Figure 2**).

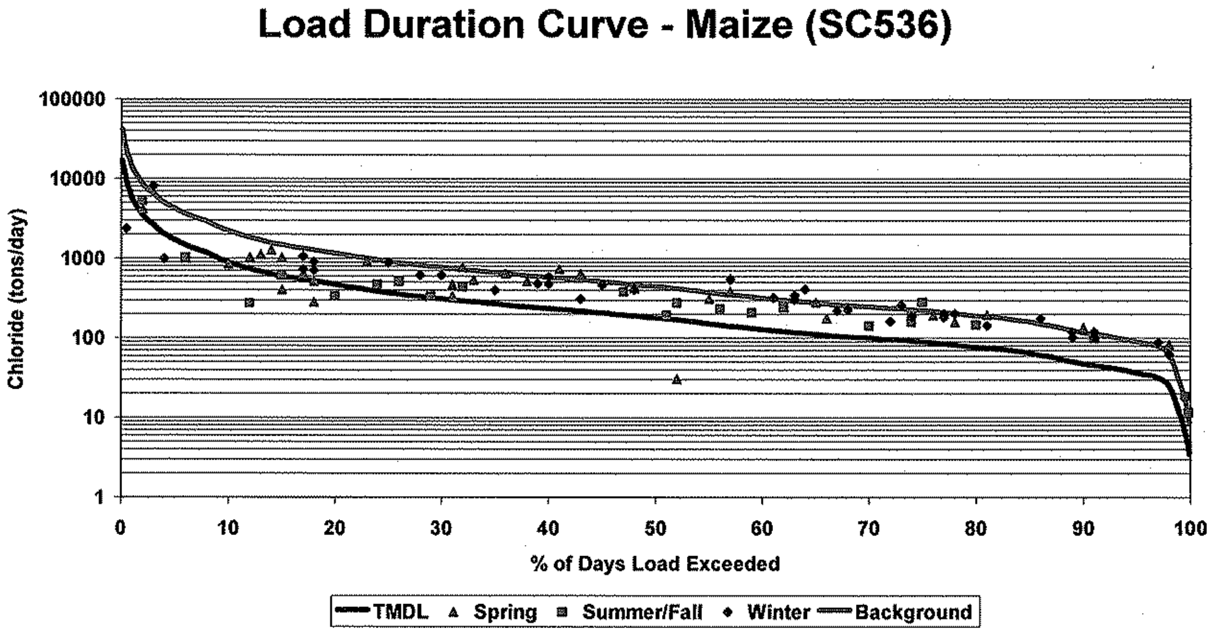
Table 5

NUMBER OF SAMPLES OVER CHLORIDE STANDARD OF 250 mg/L BY FLOW								
Station	**Season**	**0 to 10%**	**11 to 25%**	**26 to 50%**	**51 to 75%**	**76 to 90%**	**91 to 100%**	**Cum. Freq.**
Arkansas River at Maize (536)	Spring	0/3	6/9	9/9	5/6	4/4	1/1	25/32 = 78%
	Summer/Fall	1/2	1/4	4/4	9/9	1/1	3/3	19/23 = 83%
	Winter	1/3	5/5	9/9	10/10	7/7	4/4	36/38 = 95%

Table 6

NUMBER OF SAMPLES OVER CHLORIDE STANDARD OF 860 mg/L BY FLOW								
Station	**Season**	**0 to 10%**	**11 to 25%**	**26 to 50%**	**51 to 75%**	**76 to 90%**	**91 to 100%**	**Cum. Freq.**
Arkansas River at Maize (536)	Spring	0/3	0/9	0/9	0/6	0/4	0/1	0/32 = 0%
	Summer/Fall	0/2	0/4	0/4	0/9	0/1	0/3	0/23 = 0%
	Winter	0/3	0/5	09	2/10	0/7	0/4	2/38 = 5%

Figure 2. Load Curve – Maize



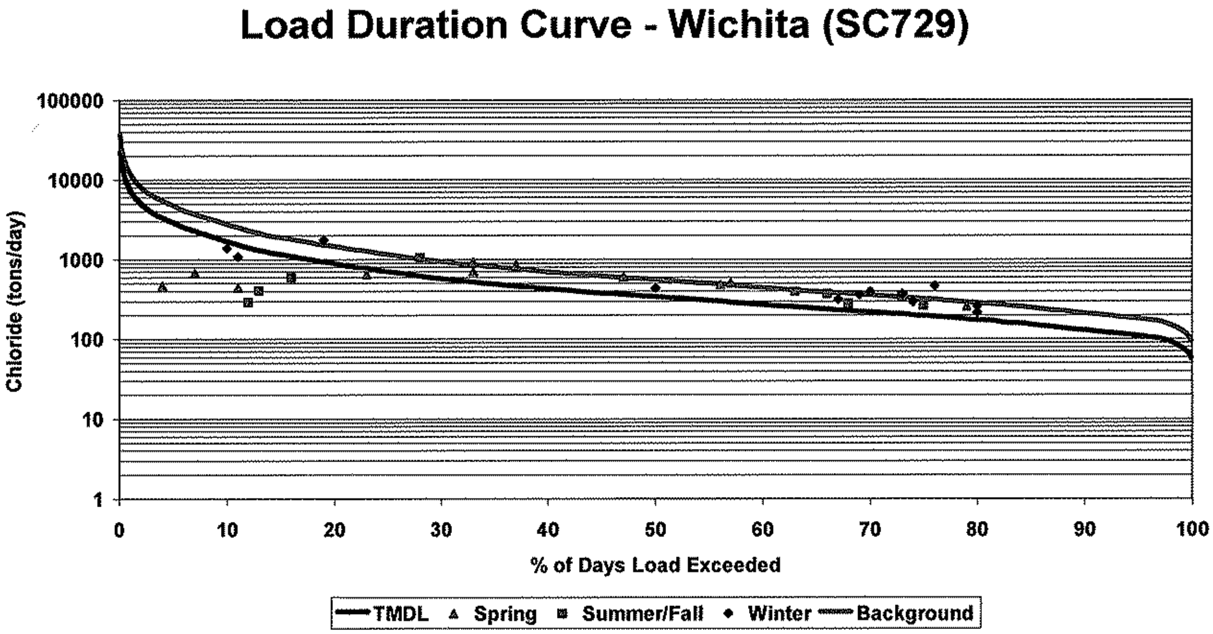
<u>Site 729 (Wichita)</u>: Excursions in each of the three defined seasons are outlined in **Table 7**. Sixty-four percent of the Spring samples and 67% of the Summer-Fall samples are above the domestic water supply standard. Eighty-three percent of the Winter samples are over the domestic supply criterion. Overall, 72% of the samples are above the domestic water supply standard.

The load curve for the limited number of samples is displayed in **Figure 3**. Since the streamflows in the Winter months are sustained mainly by the influx of the ground water, the background level at the station is determined using the Winter samples (see **Section 3**). For the Wichita station, the background level is set at 410 mg/L.

Table 7

NUMBER OF SAMPLES OVER CHLORIDE STANDARD OF 250 mg/L BY FLOW								
Station	**Season**	**0 to 10%**	**11 to 25%**	**26 to 50%**	**51 to 75%**	**76 to 90%**	**91 to 100%**	**Cum. Freq.**
Arkansas River at Wichita (729)	Spring	0/2	0/2	4/4	2/2	1/1	0/0	7/11 = 64%
	Summer/Fall	0/0	0/3	1/1	5/5	0/0	0/0	6/9 = 67%
	Winter	0/1	1/2	1/1	5/5	3/3	0/0	10/12 = 83%

Figure 3. Load Curve – Wichita



<u>Site 281 (Derby)</u>: Excursions in each of the three defined seasons are outlined in **Table 8**. Sixty-three percent of the Spring samples and 56% of the Summer-Fall samples are above the domestic water supply standard. Eighty-eight percent of the Winter samples are over the domestic supply criterion. Overall, 71% of the samples are above the domestic water supply standard. The high exceedance rate during the Winter season coincides with the low flow period of the year.

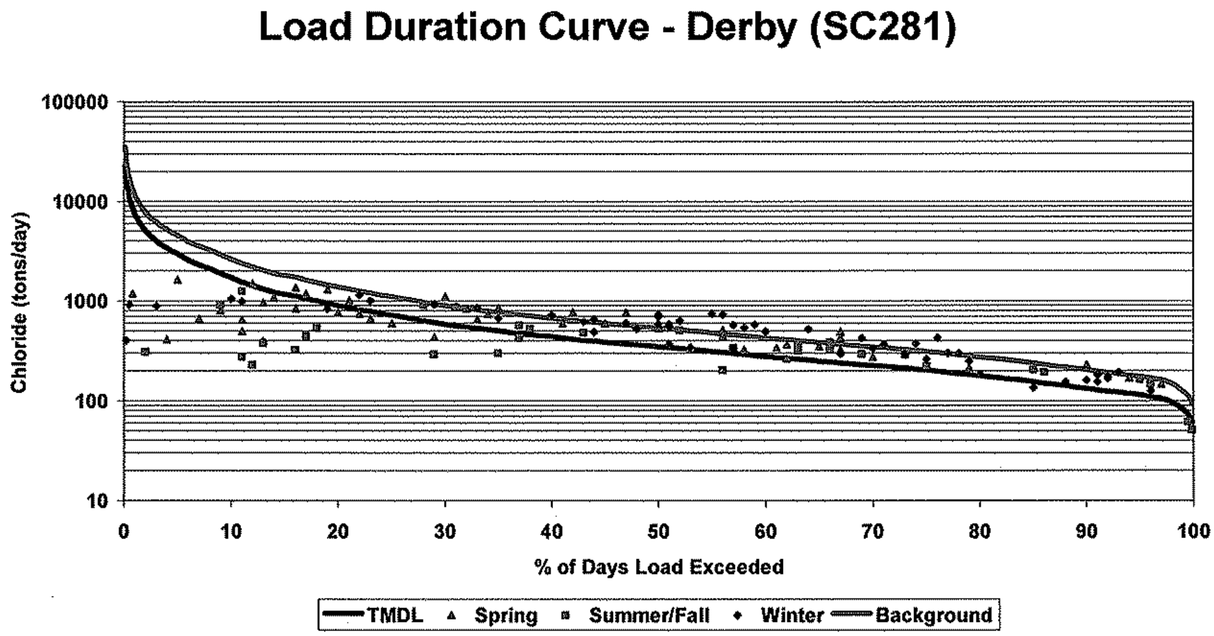
The TMDL load curve (**Figure 4**) indicates that the exceedances usually do not occur during high flow events (0-15% exceedance), suggesting high flows and stormwater runoff are not a concern for the chloride impairment. In fact, higher flows dilute the salt in the water and lower the chloride levels. At medium to low flow (>40% exceedance), the chloride standard was exceeded nearly at every point. At high to medium flow (15-40% exceedance), the standard was exceeded more than half of the time.

Since the streamflows in the Winter months are sustained mainly by the influx of the ground water, the background level at the station is determined using the Winter samples (see **Section 3**). For the Derby station, the background level is set at 385 mg/L. The background load curve indicates that the area sources are the main contributor to all the exceedances of chloride over the background concentration, since all the exceedances occurred at 30-90% exceedance flows (**Figure 4**).

Table 8

NUMBER OF SAMPLES OVER CHLORIDE STANDARD OF 250 mg/L BY FLOW								
Station	**Season**	**0 to 10%**	**11 to 25%**	**26 to 50%**	**51 to 75%**	**76 to 90%**	**91 to 100%**	**Cum. Freq.**
Arkansas River at Derby (281)	Spring	0/5	4/15	11/12	11/12	2/2	2/2	30/48 = 63%
	Summer/Fall	0/2	0/7	5/8	10/11	2/2	2/4	19/34 = 56%
	Winter	0/4	2/4	12/12	21/21	8/9	7/7	50/57 = 88%

Figure 4. Load Curve – Derby



Comparison of chloride levels between stations: The comparisons of chloride concentrations between stations (**Figures 5-7**) clearly show a general pattern of dilution from Maize to Derby. The Ark River serves as the main dilution base.

Figure 5. Maize and Derby Chloride

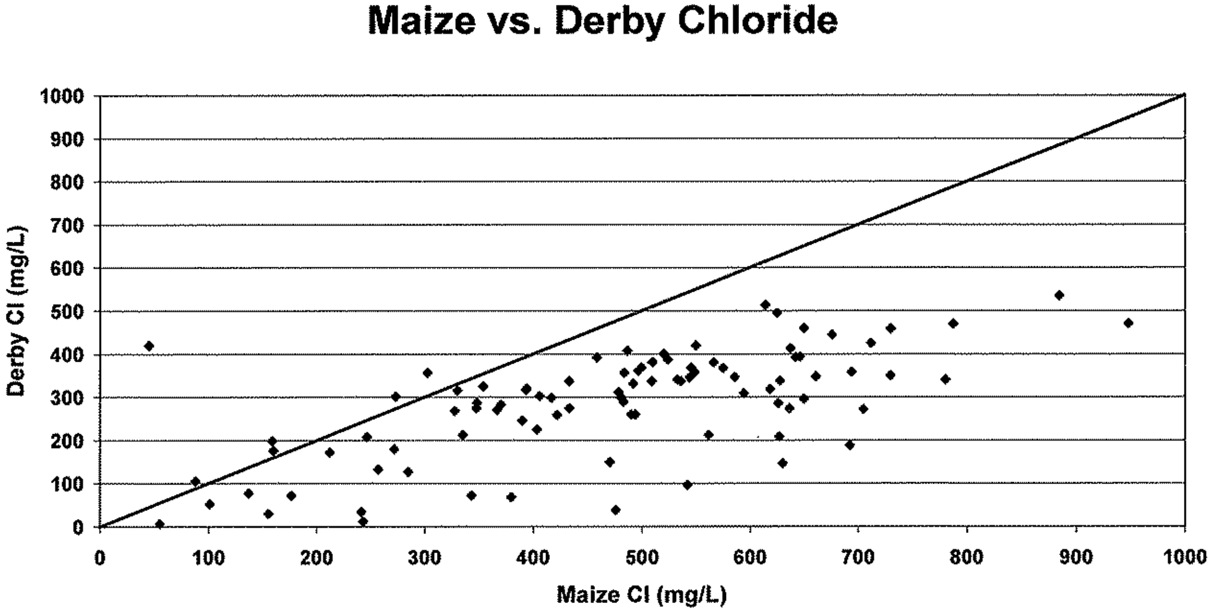


Figure 6. Maize and Wichita Chloride

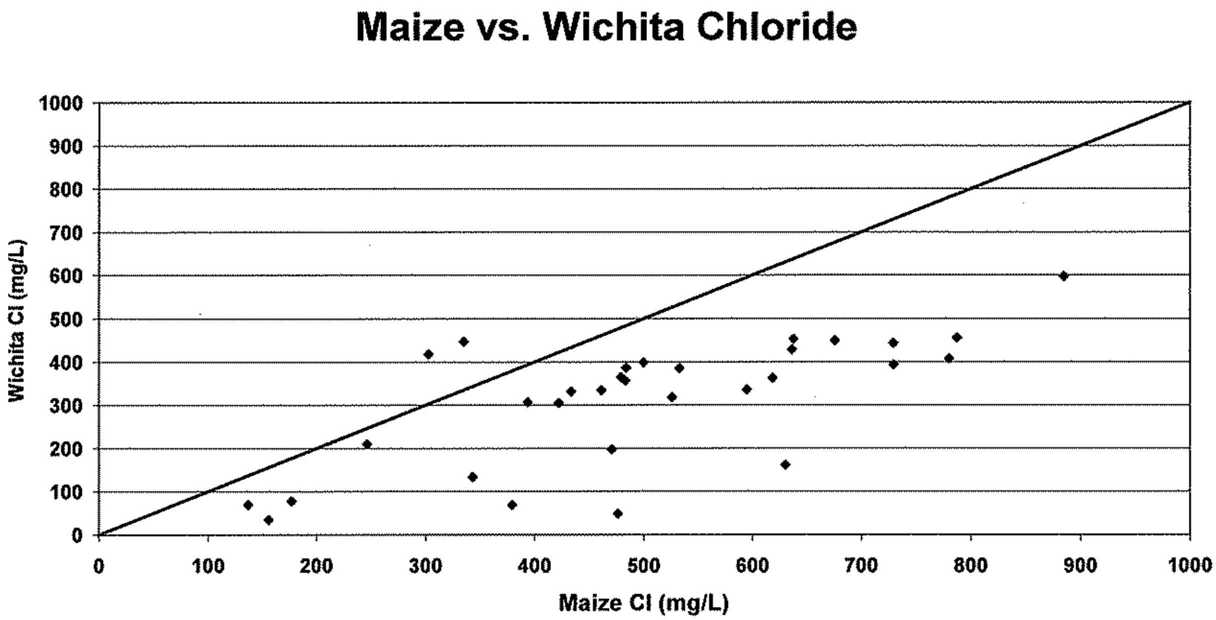
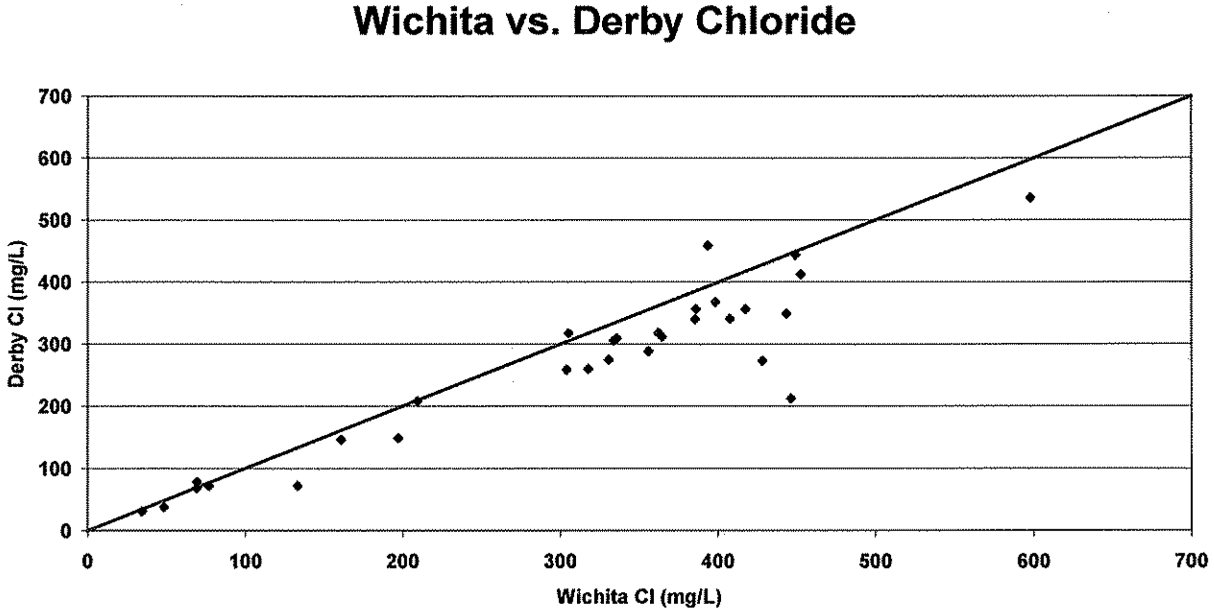


Figure 7. Wichita and Derby Chloride



Desired Endpoints of Water Quality (Implied Load Capacity) at Sites 536, 729, and 281, over 2006 – 2016

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Drinking Water Use. This TMDL will, however, be staged (**Table 9**). The current standard of 250 mg/L of chloride is used to establish the initial TMDL. Since the Standard is not achievable due to the relatively high natural contributions to the chloride load, an alternative endpoint is needed at sites 536, 729, and 281. Kansas Water Quality Standards and their Implementation Procedures for Surface Water allow for a numerical criterion based on natural background concentrations to be established, particularly from ambient samples taken at flows less than median flows. The Stage II end points are set at the background concentrations tentatively for sites 536, 729, and 281. The specific stream criteria to supplant the general standard will be developed concurrent with Stage One of this TMDL.

Seasonal variation has been incorporated in this TMDL through the documentation of seasonal patterns of elevated chloride levels, especially during periods of low flows and extended drought. Achievement of the endpoints indicate loads are within the loading capacity of the stream, water quality standards are attained, and full support of the designated uses of the stream has been achieved.

Table 9. Endpoints

Site	Stage I End Point (mg/L)	Stage II End Point (mg/L)
536 (Maize)	250	**620**
729 (Wichita)	250	**410**
281 (Derby)	250	**385**

3. SOURCE INVENTORY AND ASSESSMENT

Chloride background assessment: Chloride along the Ark River is driven by chloride seen at Maize (**Figures 5-7**). The chloride levels at Maize are a function of upstream sources. Generally, chloride is diluted below Maize by (1) Little Ark flows; (2) groundwater seepage from the Equus Beds Aquifer; and (3) wastewater from Wichita.

NPDES:

There are three wastewater treatment facilities that discharge medium to large amounts of chloride into the streams (**Figure 1**). They are listed in **Table 10** by HUC14. The low-discharging facilities are listed in **Table 11** and not included for load allocations in Section 4. The largest facility is the Wichita Wastewater Treatment Plants 1 and 2. The chloride concentration in the effluent is averaged at 214 mg/L. The discharges from the facility are actually diluting the chloride in the Arkansas River.

Table 10. High-Impact Wastewater Treatment Facilities

KS #	NPDES #	Facility Name	Receiving Stream (nain stem)	Design Flow (MGD)	Actual Flow (MGD)	Ave Cl (mg/L)
HUC14: 11030010(020080)						
I-AR94-PO83	KS0093874	Brooks Landfill GW Remediation Project	Arkansas River	0.576	0.400	389
HUC14: 11030013(010050)						
I-AR94-PO80	KS0092762	Gilbert & Mosley Remediation Site	Arkansas River via Chisholm Cr	1.66	1.22	118
HUC14: 11030013(010060)						
M-AR94-IO01	KS0043036	Wichita WWTP 1 and 2	Arkansas River	54	35.3	214

Table 11. Low-Impact Wastewater Treatment Facilities

KS #	NPDES #	Facility Name	Receiving Stream (main stem)	Design Flow (MGD)	Actual Flow (MGD)	Ave Cl (mg/L)
HUC14: 11030013(010050)						
I-AR94-PO70	KS0091421	Coleman Company	Ark River via Chisholm Cr.	0.230	0.137	NA
I-AR94-PO21	KS0000850	York International	Ark River via Chisholm Cr.	1.082	0.673	NA
I-AR94-PO78	KS0092118	El Paso Merchant	Ark River via Chisholm Cr.	1.296	NA	77
I-AR94-PO76	KS0091855	Coleman Co (A & B)	Ark River	0.259	0.253	123
I-AR94-PO04	KS0000183	Raytheon Aircraft	Ark River via Gypsum Cr	0.085	0.071	NA
HUC14: 11030013(010060)						
I-AR94-PO31	KS0086703	Globe Engineering	Ark River	0.466	0.335	107
I-AR94-PO62	KS0000825	Wescon Products	Ark River	0.648	0.397	?
I-AR94-C050	KS0089010	Senior Aerospace	Ark River	0.0075	NA	180
I-AR94-PO46	KS0088757	Boeing Company	Ark River	0.274	NA	73

NA – data not availble

Irrigation: Irrigation use of the surface or ground water is very limited in the area because of the dominant urban land type in the area (**Figures 8 and 9**). Irrigation has minimum impacts on the chloride levels in the streams.

Runoff: Stormwater runoff or high flow events are not a cause or contributing factor for the chloride impairment in the area (**Figures 2-4**) since chloride is diluted below 250 mg/L at high flows.

Brine from Oil and Gas: A few oil fields are scattered in the area (**Figure 10**). Their effects to the watershed are probably localized to the production areas and not contributing to the chloride impairments.

Figure 8. Land Use Map

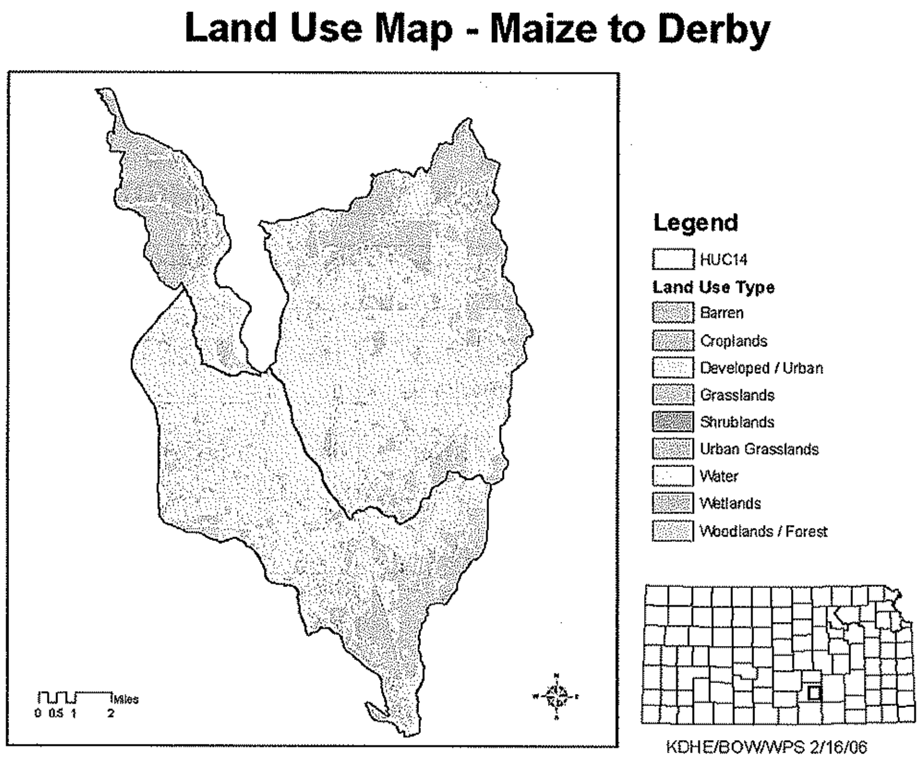


Figure 9. Point of Diversion Map

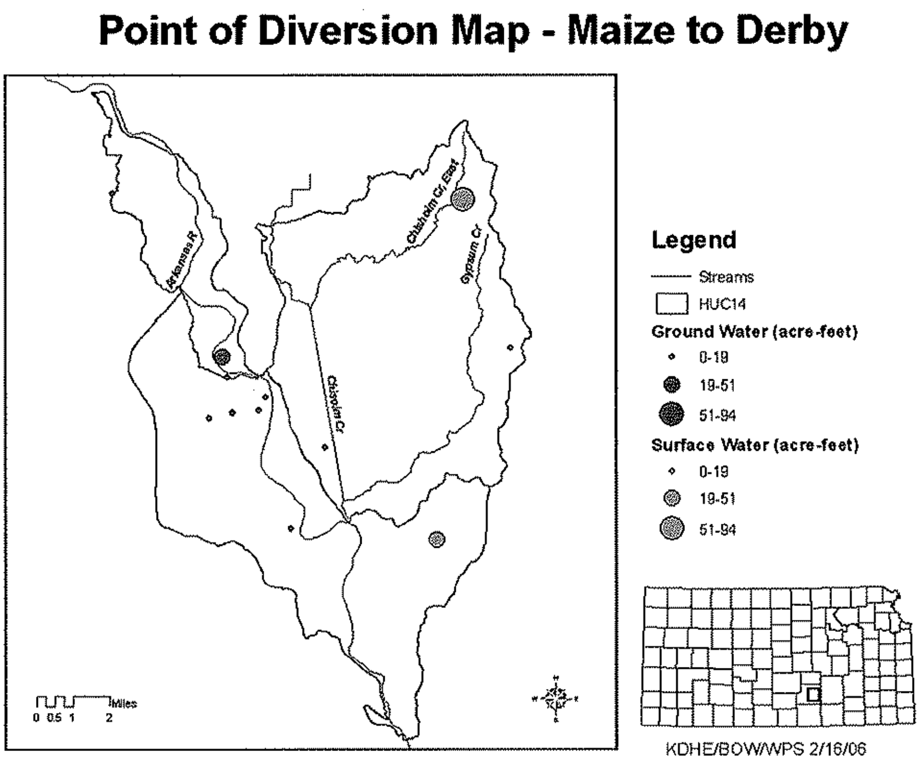
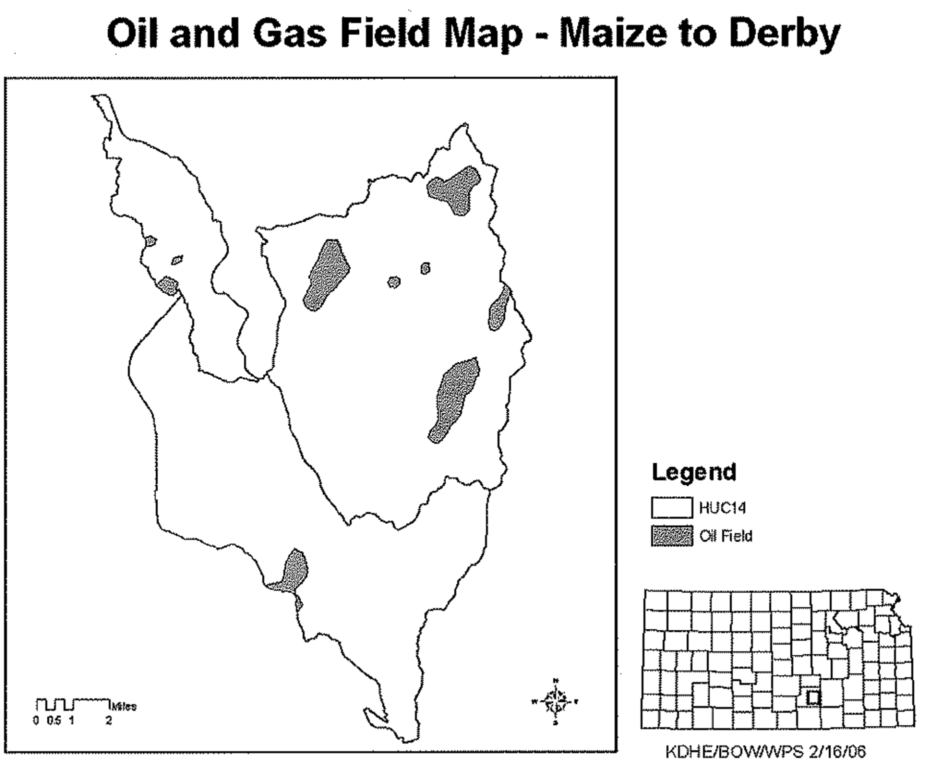


Figure 10. Oil and Gas Field Map



4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Point and Non-point Sources: Mass balance analysis was used to allocate the chloride loading in the sub-basins. Data from Dec 91, a known period of low flows, were used to calibrate the tributary flows, groundwater seepages, and point sources discharges. After the baseflow scenario was calibrated, twenty additional scenarios with different conditions were constructed. Additionally, a scenario involving May 1992 low flow conditions was used to evaluate the impact of drought. The conditions and loads of the twenty-two scenarios are listed in **Table 12**. The resulting chloride concentrations from the scenarios are listed in **Table 13**. The spreadsheets of the baseline, decreased load at Maize, worst-case (GW project), and drought scenarios are provided in **Appendix C**.

The point source discharges generally have lower chloride concentrations than the levels in the Arkansas River, and therefore help to dilute the chloride in the stream. Even though the chloride loads from the Wichita Wastewater Treatment Plant 1 & 2 account for 26% of the total loads at Derby (baseflow), the effluent from the plant actually reduces the chloride concentrations in the Arkansas River as seen in Scenario 2. On the other hand, when the chloride concentrations in the effluent increase, the chloride levels in the stream also rise as seen in Scenarios 3 and 4.

Upstream chloride loads at Maize are the major contributor to the high chloride levels in the area. At the baseflow, the loads at Maize account for 50% of the loads at Derby. When the chloride levels or the stream flows are lowered at Maize, the chloride concentrations at Derby decrease significantly (Scenarios 5-7).

The natural background loadings through the ground water seepage are also significant in the area due to their total quantities. At the baseflow, the chloride loads from the ground water seepage contribute about 10% of the loads at Derby. Since the chloride concentration in the ground water is approximately equivalent to the levels in the Arkansas River according to our estimates, the seepage does not cause or exacerbate the impairment.

The Little Arkansas River and the Cowskin Creek Floodway are clean streams concerning chloride and provide further dilution to the chloride in the Arkansas River. Lower flows from the Little Ark River will result in higher chloride at Derby (Scenarios 8 and 9).

Addition of a ground water remediation project above the Wichita Wastewater Treatment Plant can have huge impacts on the chloride loadings and concentrations in the Arkansas River (Scenarios 10-21 and Figure 9). When the discharge concentrations are lower than the levels in the stream, the discharges actually lower the chloride levels in the Arkansas River (Scenarios 10-12 and Figure 9). When the discharge concentrations are higher than the stream levels and the discharge flows are larger than 1 MGD, the new ground water remediation project can cause significant increases of the chloride levels in the Arkansas River (Scenarios 13-21 and Figure 11).

Drought may increase the chloride levels in the rivers by decreasing the fresh water input into the streams. The higher chloride loads and concentrations in the May 92 scenario are likely caused by a prolonged period of drought the region was experiencing.

Table 12. Loads and Allocations (tons/day)

Allocation	Base-flow	Design Flow A	Design Flow B	Wichita @ 400	Maize @ 600	Maize @ 500	Maize @ 5cfs	L. Ark @ 5cfs	L. Ark @ 10cfs	GWR @ 250A	GWR @ 250B	GWR @ 250C	GWR @ 500A	GWR @ 500B	GWR @ 500C	GWR @ 750A	GWR @ 750B	GWR @ 750C	GWR @ 1000A	GWR @ 1000B	GWR @ 1000C	May 92
Lower Ark River at Maize	62.5	62.5	62.5	62.5	59.9	50.0	8.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	82.5
Little Ark River	13.3	13.3	13.3	13.3	13.3	13.3	13.3	1.6	3.1	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	7.2
Wasteload Allocations	**33.4**	**50.0**	**92.0**	**61.3**	**33.4**	**33.4**	**33.4**	**33.4**	**33.4**	**34.4**	**43.8**	**54.2**	**35.5**	**54.2**	**75.1**	**36.5**	**64.7**	**96.0**	**37.5**	**75.1**	**116.9**	**33.4**
Cowskin Creek	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.7
GW Seepage	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	44.6
Lower Ark River at Derby	125.6	142.2	184.2	153.5	123.0	113.1	71.6	113.9	115.4	126.6	136.0	146.4	127.7	146.4	167.3	128.7	156.9	188.2	129.7	167.3	209.1	168.3

1	Baseflow	Dec 91 conditions, point source flow at 2/3 of the design flow
2	Design Flow A	Dec 91 conditions, point source flow at the design flow
3	Design Flow B	Dec 91 conditions, point source flow at the design flow; Wichita WWTP increased to 400 mg/L
4	Wichita @ 400	Dec 91 conditions, point source flow at 2/3 of the design flow; Wichita WWTP increased to 400 mg/L
5	Maize @ 600	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc. reduced to 600 mg/L
6	Maize @ 500	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc. reduced to 500 mg/L
7	Maize @ 5cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc.at 694 mg/L, flow at 5cfs
8	L. Ark @ 5cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Little Ark R flow at 5 cfs
9	L. Ark @ 10cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Little Ark R flow at 10 cfs
10	GWRem @ 250A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 1 MGD
11	GWRem @ 250B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 10 MGD
12	GWRem @ 250C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 20 MGD
13	GWRem @ 500A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 500 mg/L, 1 MGD
14	GWRem @ 500B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 500 mg/L, 10 MGD
15	GWRem @ 500C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 500 mg/L, 20 MGD
16	GWRem @ 750A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 750 mg/L, 1 MGD
17	GWRem @ 750B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 750 mg/L, 10 MGD
18	GWRem @ 750C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 750 mg/L, 20 MGD
19	GWRem @ 1000A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 1 MGD
20	GWRem @ 1000B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 10 MGD
21	GWRem @ 1000C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 20 MGD
22	May 92	May 92 conditions, point source flow at 2/3 of the design flow

Table 13. Chloride Concentration (mg/L)

Location	Base-flow	Design Flow A	Design Flow B	Wichita @ 400	Maize @ 600	Maize @ 500	Maize @ 5cfs	L. Ark @ 5cfs	L. Ark @ 10cfs	GWR @ 250A	GWR @ 250B	GWR @ 250C	GWR @ 500A	GWR @ 500B	GWR @ 500C	GWR @ 750A	GWR @ 750B	GWR @ 750C	GWR @ 1000A	GWR @ 1000B	GWR @ 1000C	May 92
Lower Ark River at Maize	626	626	626	626	600	500	626	626	626	626	626	626	626	626	626	626	626	626	626	626	626	694
Lower Ark River at Derby	285	274	355	348	279	256	201	335	327	284	282	279	287	303	319	289	325	359	291	346	399	359

1	Baseflow	Dec 91 conditions, point source flow at 2/3 of the design flow
2	Design Flow A	Dec 91 conditions, point source flow at the design flow
3	Design Flow B	Dec 91 conditions, point source flow at the design flow; Wichita WWTP increased to 400 mg/L
4	Wichita @ 400	Dec 91 conditions, point source flow at 2/3 of the design flow; Wichita WWTP increased to 400 mg/L
5	Maize @ 600	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc. reduced to 600 mg/L
6	Maize @ 500	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc. reduced to 500 mg/L
7	Maize @ 5cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Maize conc.at 694 mg/L, flow at 5cfs
8	L. Ark @ 5cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Little Ark R flow at 5 cfs
9	L. Ark @ 10cfs	Dec 91 conditions, point source flow at 2/3 of the design flow; Little Ark R flow at 10 cfs
10	GWRem @ 250A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 1 MGD
11	GWRem @ 250B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 10 MGD
12	GWRem @ 250C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 250 mg/L, 20 MGD
13	GWRem @ 500A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 500 mg/L, 1 MGD
14	GWRem @ 500B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 500 mg/L, 10 MGD
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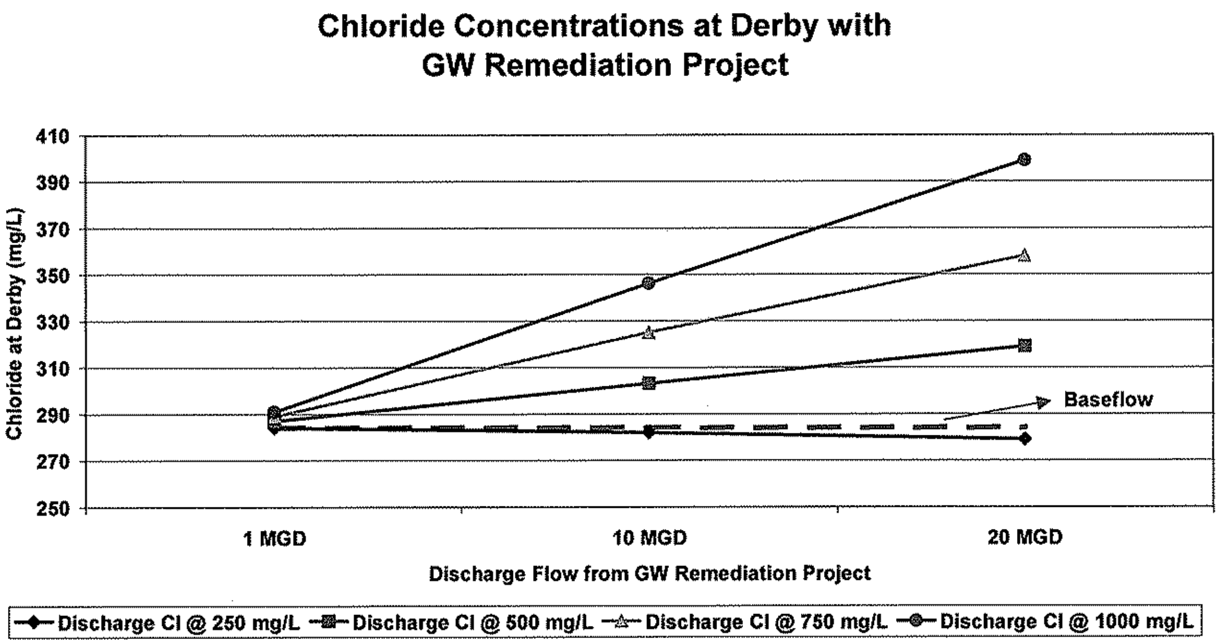
18	GWRem @ 750C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 750 mg/L, 20 MGD
19	GWRem @ 1000A	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 1 MGD
20	GWRem @ 1000B	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 10 MGD
21	GWRem @ 1000C	Dec 91 conditions, point source flow at 2/3 of the design flow; a new GW Remediation Project above Wichita WWTP, 1000 mg/L, 20 MGD
22	May 92	May 92 conditions, point source flow at 2/3 of the design flow

Figure 11. Chloride Levels at Derby with a Hypothetical GW Remediation Project



Defined Margin of Safety: The Margin of Safety is implicitly set because the area sources are the main contributors for the chloride impairment and the endpoints are established from the Winter data when man-made influences are minimal. Furthermore, loadings from the point sources act as a dilution base for natural chloride contributions.

State Water Plan Implementation Priority: Because the chloride impairment is due to upstream loading and geologic sources, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: The watersheds lie within the Lower Arkansas Basin (HUC 8: part of 11030010, part of 11030013) with priority rankings of 19 and 6, respectively (Priority for restoration work).

Priority HUC 11s and Stream Segments: Because of the natural geologic contribution of this impairment, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor and limit any anthropogenic contributions of chloride loading to river.
2. Establish alternative background criterion.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. NPDES and state permits for facilities in the watershed will be renewed after 2007 with chloride monitoring and any appropriate permit limits which protects the background concentrations at any existing or emerging drinking water point of diversion on these streams as well as aquatic life and ground water recharge.

Non-Point Source Pollution Technical Assistance - KDHE

a. Evaluate any potential anthropogenic activities that might contribute chloride to the river as part of an overall Watershed Restoration and Protection Strategy.

Water Quality Standards and Assessment - KDHE

a. Establish background levels of chloride for the river.

Timeframe for Implementation: Development of a background level-based water quality standard should be accomplished with the water quality standards revision.

Targeted Participants: Primary participant for implementation will be KDHE.

Milestone for 2011: The year 2011 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from the watersheds should indicate no evidence of increasing chloride levels relative to the conditions seen in 1990-2005. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

Delivery Agents: The primary delivery agent for program participation will be KDHE.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the Kansas Water Plan.

6. The *Kansas Water Plan* and the Lower Ark Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund, annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration.

Effectiveness: Minimal control can be exerted on natural contributions to loading.

6. MONITORING

KDHE will continue to collect bimonthly samples at Stations 511, 512, and 266, including chloride samples, in each of the three defined seasons over 2006-2011. Based on that sampling, the priority status will be evaluated in 2012 including application of numeric criterion based on background concentrations. Should impaired status remain, the desired endpoints under this TMDL will be refined and more intensive sampling will be needed under specified seasonal flow conditions after 2012.

Monitoring of chloride levels in effluent will be a condition of NPDES and state permits for facilities. This monitoring will continually assess the contributions of chloride in the wastewater effluent released to the stream.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Lower Arkansas Basin were held on June 7, 2006 in Hutchinson. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Lower Arkansas Basin.

Public Hearing: Public Hearings on the TMDLs of the Lower Arkansas Basin were held on June 7, 2006 in Hutchinson. The public record was held open until June 20, 2006. No comments were received by KDHE.

Basin Advisory Committee: The Lower Arkansas Advisory Committee met to discuss the TMDLs in the basin on June 7, 2006.

Milestone Evaluation: In 2011, an evaluation will be made as to the degree of implementation that has occurred within the watershed and current condition of the Arkansas River. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The stream will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2006-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

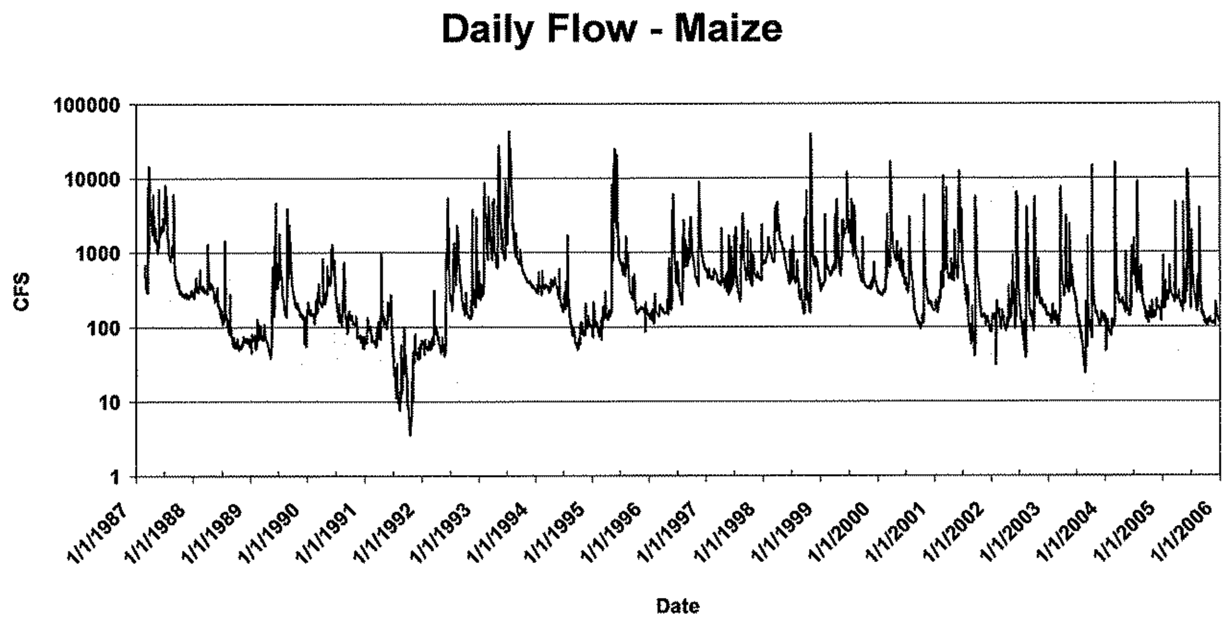
Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2006 which will emphasize implementation of TMDLs. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2007-2011.

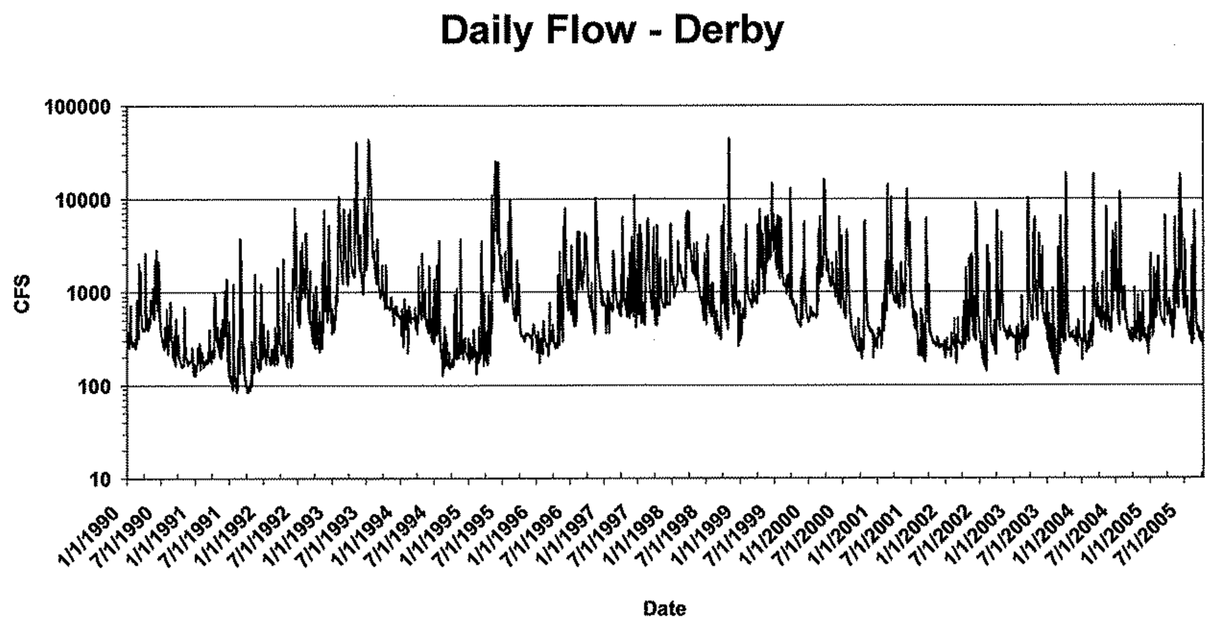
Revised 6/28/2006

Bibliography

1. Kansas Ground Water, An Introduction to the State's Water Quantity, Quality, and Management Issues, compiled by Rex Buchanan and Robert W. Buddemeier. Kansas Geological Survey, Educational Series 10. 1993. http://www.kgs.ku.edu/Publications/Bulletins/ED10/index.html.

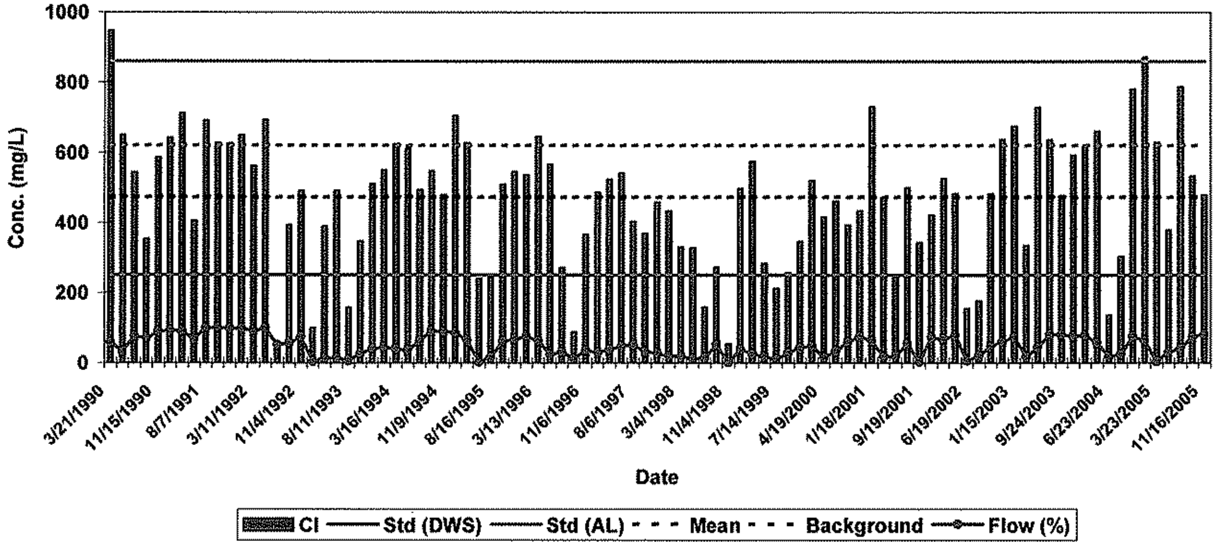
Appendix A. USGS Daily Flows Charts



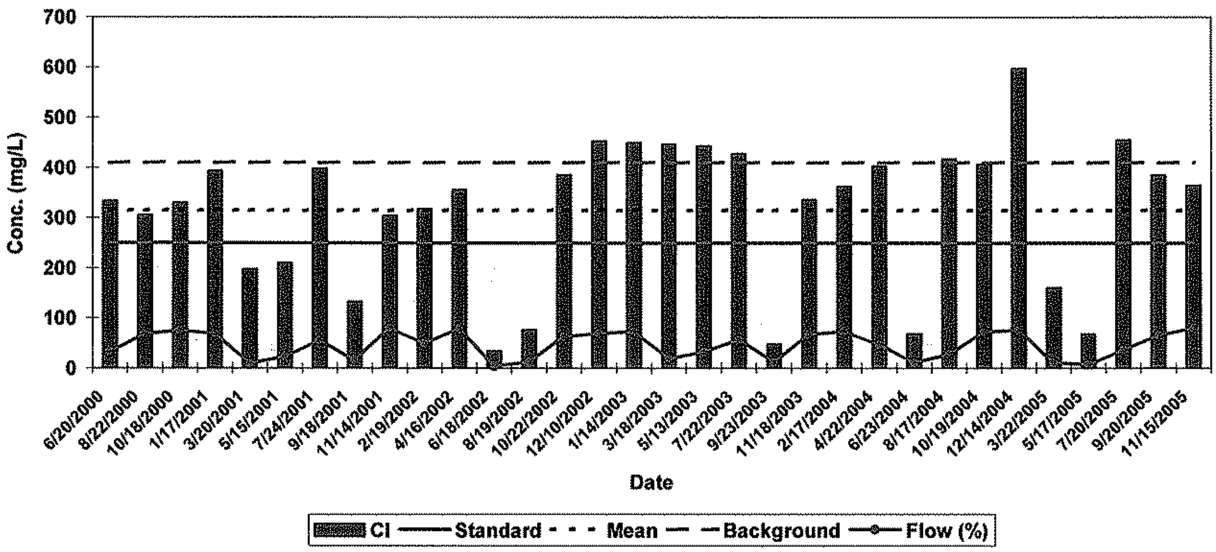


Appendix B. Charts of Chloride Concentrations over Time

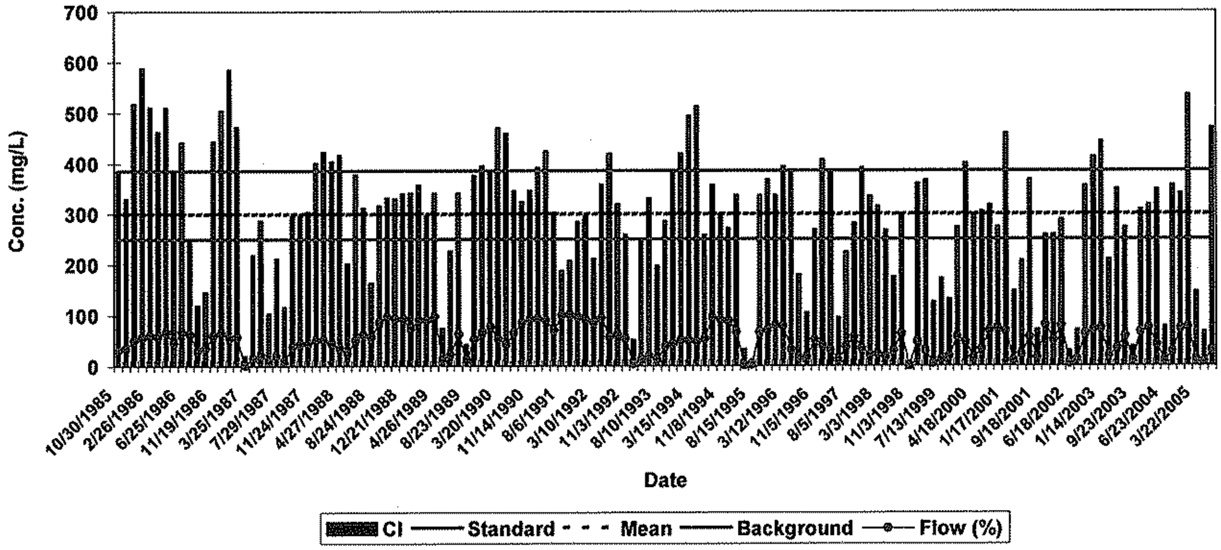
Chloride - Maize (SC536)



Chloride - Wichita (SC729)



Chloride - Derby (SC281)



Appendix C. Load Allocation Calculation Spreadsheets

Baseflow (Dec 91)

Site	Flow %	Fac_Name	Ave Flow* (cfs)	Ave Conc (mg/L)	WLA (tons/day)	LA (tons/day)	WLA+LA (tons/day)	Dec 91 Conc. (mg/L)	Dec 91 Flow	Load (tons/day)
Maize (536)	98%							626	**37**	62.54
		Upstream Flow	**37**	**626**			**62.54**			
		Total	**37.00**	**626.00**			**62.54**			
Maize (536)	98%	**Flow from Maize**	**37.00**	**626.00**			**62.54**			
Wichita (728)	75%	**Flow from Little Ark R****	**42.57**	**115.65**			**13.29**			
		Brooks Landfill	**0.59**	**389**	**0.62**					
		Gilbert & Mosley	**1.71**	**118**	**0.55**					
		Wichita WWTP 1 & 2	**55.70**	**214**	**32.18**					
Wichita (288)	95%	Flow from Cowskin Cr	2.81	53.40			0.41			
		GW Seepage	**23**	***257***		**15.96**				
Derby (281)	96%							285	**163**	125.43
		Total	**163.39**	**284.60**			**125.55**			

* Flow for point source is 2/3 of the design flow converted from MGD to CFS.
** KDHE chemistry data in Nov 2001
All Italic numbers are estimates.
Wichita (728) site is on the West Central Avenue Bridge.
Wichita (288) site is 0.4 miles below the confluence with the Valley Ctr Floodway.

Maize at 500 mg/L

Site	Flow %	Fac_Name	Ave Flow* (cfs)	Ave Conc (mg/L)	WLA (tons/day)	LA (tons/day)	WLA+LA (tons/day)	Dec 91 Conc. (mg/L)	Dec 91 Flow	Load (tons/day)
Maize (536)	98%							626	**37**	62.54
		Upstream Flow	**37**	**500**			**49.95**			
		Total	**37.00**	**500.00**			**49.95**			
Maize (536)	98%	**Flow from Maize**	**37.00**	**500.00**			**49.95**			
Wichita (728)	75%	**Flow from Little Ark R****	**42.57**	**115.65**			**13.29**			
		Brooks Landfill	**0.59**	**389**	**0.62**					
		Gilbert & Mosley	**1.71**	**118**	**0.55**					
		Wichita WWTP 1 & 2	**55.70**	**214**	**32.18**					
Wichita (288)	95%	Flow from Cowskin Cr	2.81	53.40			0.41			
		GW Seepage	**23**	***257***		**15.96**				
Derby (281)	96%							285	**163**	125.43
		Total	**163.39**	**256.06**			**112.96**			

* Flow for point source is 2/3 of the design flow converted from MGD to CFS.
** KDHE chemistry data in Nov 2001
All Italic numbers are estimates.
Wichita (728) site is on the West Central Avenue Bridge.
Wichita (288) site is 0.4 miles below the confluence with the Valley Ctr Floodway.

Groundwater Remediation Project Discharging 10MGD at 500 mg/L

Site	Flow %	Fac_Name	Ave Flow* (cfs)	Ave Conc (mg/L)	WLA (tons/day)	LA (tons/day)	WLA+LA (tons/day)	Dec 91 Conc. (mg/L)	Dec 91 Flow	Load (tons/day)
Maize (536)	98%							626	37	62.54
		Upstream Flow	37	626			62.54			
		Total	37.00	626.00			62.54			
Maize (536)	98%	**Flow from Maize**	37.00	626.00			62.54			
Wichita (728)	75%	**Flow from Little Ark R****	42.57	115.65			13.29			
		Brooks Landfill	0.59	389	0.62					
		Gilbert & Mosley	1.71	118	0.55					
		Wichita WWTP 1 & 2	55.70	214	32.18					
		GW Rem Project	15.47	500	20.88					
Wichita (288)	95%	Flow from Cowskin Cr	2.81	53.40			0.41			
		GW Seepage	23	*257*		15.96				
Derby (281)	96%							285	163	125.43
		Total	178.86	303.23			146.43			

* Flow for point source is 2/3 of the design flow converted from MGD to CFS.
** KDHE chemistry data in Nov 2001
All Italic numbers are estimates.
Wichita (728) site is on the West Central Avenue Bridge.
Wichita (288) site is 0.4 miles below the confluence with the Valley Ctr Floodway.

May 92 Conditions

Site	Flow %	Fac_Name	Ave Flow* (cfs)	Ave Conc (mg/L)	WLA (tons/day)	LA (tons/day)	WLA+LA (tons/day)	May 92 Conc. (mg/L)	May 92 Flow	Load (tons/day)
Maize (536)	98%							694	44	82.45
		Upstream Flow	44	694			82.45			
		Total	44.00	694.00			82.45			
Maize (536)	98%	**Flow from Maize**	44.00	694.00			82.45			
Wichita (728)	95%	**Flow from Little Ark R****	18.70	143.40			7.24			
		Brooks Landfill	0.59	389	0.62					
		Gilbert & Mosley	1.71	118	0.55					
		Wichita WWTP 1 & 2	55.70	214	32.18					
Wichita (288)	95%	Flow from Cowskin Cr	3.00	83.90			0.68			
		GW Seepage	50.00	*330*		44.550				
Derby (281)	94%							358	174	168.19
		Total	173.71	358.78			168.27			

* Flow for point source is 2/3 of the design flow converted from MGD to CFS.
** KDHE chemistry data in July 2003
All Italic numbers are estimates.
Wichita (728) site is on the West Central Avenue Bridge.
Wichita (288) site is 0.4 miles below the confluence with the Valley Ctr Floodway.